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Research Report

Predictors of reported consumption of low-nutrient-density foods in a 24-h recall by 8–16 year old US children and adolescents

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Abstract

The purpose of this study was to develop an explanatory model to predict the number of low-nutrient-density (LND) foods reported in a 24-h recall by US children and adolescents using data from the third National Health and Nutrition Examination Survey. The reported number of LND foods was estimated from 24-h dietary recall data for 8–16 year old respondents ($n = 4137$; 2024 males and 2113 females). The LND foods included—baked and dairy desserts, sweeteners, salty snacks, visible/discretionary fat, and miscellaneous. The predictive ability of socio-demographic, family, weight/dieting related, life-style or food consumption related subject characteristics was determined using multiple linear regression analyses. The strongest independent negative predictor of the reported number of LND foods was the amount of nutrient-dense foods from the five major food groups. In addition, number of eating occasions reported was a significant independent positive predictor, and the weekly frequency of consuming a complete school lunch was a significant independent negative predictor of the reported number of LND foods. These models explained approximately 55% of the variance in LND food reporting in both males and females. Socio-demographic, family, body weight, or lifestyle characteristics contributed little to predicting the number of LND foods reported in a 24-h recall.
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Keywords: Low nutrient density foods; Children; Adolescents; Dietary patterns; NHANES III

Introduction

Energy-dense foods of modest nutritional value are widely consumed by the US population (Kann, Warren, Harris, & Collins, 1993; Kant, 2000, 2003; Kant & Schatzkin, 1994). Nearly a third of the daily energy intake in the diets of adults and children in the US may be contributed by low-nutrient-density (LND) foods (Kant, 2000, 2003; Kant & Schatzkin, 1994). Increasing LND food reporting is linked to a lower likelihood of meeting the standard of intake of micronutrients (Ballew, Kuester, & Gillespie, 2000; Harnack, Stang, & Story, 1999; Kant, 2000, 2003; Kant & Schatzkin, 1994). LND food reporting is also associated with higher energy intakes (Kant, 2000, 2003; Kant & Schatzkin, 1994), which may be one of the contributing factors to increasing adiposity in the US population (Ludwig, Peterson, & Gortmaker, 2001; Troiano & Flegal, 1998). However, surprisingly little is known about predictors of LND food intake. Understanding predictors of LND food intake is important to facilitate development and targeting of effective intervention strategies.

The purpose of this study was to examine socio-demographic, life-style, health, and food consumption related characteristics associated with reported LND food consumption in a 24-h recall by a nationally representative sample of US children and adolescents.

Methods

This study used data from the third National Health and Nutrition Examination Survey (NHANES III), 1988–1994. The NHANES III is a multistage, stratified, probability sample of the non-institutionalized, civilian US population, aged 2 months and over (National Center for Health Statistics, 1994). The survey was conducted by the National Center for Health Statistics, (NCHS) and included

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administration of a questionnaire at home and a full medical exam along with a battery of tests in a special mobile examination center (MEC). Demographic and medical history information was obtained during the household interview. The MEC exam included a physical and dental exam, dietary interview, body measurements including weight, height, and circumference at various body sites, and collection of blood and urine samples (National Center for Health Statistics, 1994).

Dietary assessment method

A 24-h dietary recall was collected by a trained dietary interviewer in a MEC interview using an automated, microcomputer based interview and coding system (National Center for Health Statistics, 1994). The type and amount of foods consumed were recalled using recall aids such as abstract food models, special charts, measuring cups, and rulers to help in quantifying the amounts consumed. Special probes were used to help the recall of commonly forgotten items such as condiments, accompaniments, and fast foods, etc.

Analytic sample: All children aged 8–16 with a 24-h recall considered complete and reliable by the NCHS were eligible for inclusion in this study ($n = 4137$; 2024 males and 2113 females) (National Center for Health Statistics, 1997).

Assessment of intake of low-nutrient-density foods

To determine the intake of LND foods, it was necessary to identify foods belonging in this category from those reported in the 24-h dietary recall. As a first step, the 2578 foods reported by the analytic sample were classified as belonging to one or more of the five major food groups (dairy, fruit, grain, meat, and vegetable) or the LND food group using methods we have described previously (Kant, 2000; Kant & Schatzkin, 1994; Kant, Schatzkin, Block, Ziegler, & Nestle, 1991). The assignment of foods into the five major food groups or the LND group was based primarily on how the foods are traditionally used in the diet. Therefore, the LND foods in this study were foods that could not be grouped into a major food group as defined below. The dairy group included milk, yogurt, cheese, and buttermilk but excluded butter, cream cheese and dairy desserts. The fruit group included all fresh, frozen, dried, and canned fruits and fruit juices but excluded fruit drinks. The grain group included all breads, cereals, pastas, and rice, but excluded pastries. The meat group included meat, poultry, fish, eggs, and meat alternates such as dried beans, nuts, and seeds. The vegetable group included all raw or cooked fresh, frozen, and canned vegetables and juices. Mixed dishes containing foods from several groups were grouped into all the relevant groups. Foods excluded from these major food groups were considered as the LND foods and included: (1) visible fat—butter, oil, dressings, and gravies, etc. (2) sweeteners—sugar, syrup, candy, carbonated and non-carbonated beverages, etc. (3) baked and dairy desserts—cookies, cakes, pies, pastries, ice cream, puddings, and cheese cakes, etc. (4) salted snacks—potato, corn, and tortilla chips, etc. and (5) coffee and tea. We chose to include coffee, tea, and beverages sweetened with artificial sweeteners in the LND group because their use in the diet is similar to that of sweetened beverages. However, these beverages comprised only 3.2% of all LND foods mentioned by the analytic sample.

The number of eating episodes or occasions reported was operationalized using previously described methods (Kant, Schatzkin, Ballard-Barbash, & Graubard, 1995). The NHANES III dietary recall data lists all foods consumed at one eating occasion under the same time of day. We considered all foods and beverages reportedly consumed at each discrete clock time in the 24-h recall to constitute one eating occasion regardless of amounts reported.

Statistical analyses

The LND foods variable was operationalized as the number of LND foods reported in the recall. We chose this form of the LND variable over the LND variable expressed as grams of foods or percentage of energy from LND foods because studies show that estimation of amounts of foods may be especially problematic in children (Livingstone & Robson, 2000; Lytle, Nichaman, & Obarzanek, et al., 1993; Matheson, Hanson, McDonald, & Robinson, 2002; Weber, Cunningham-Sabo, & Skipper, et al., 1999). The grams of LND foods and percentage of energy from LND foods variables are a function of both the number and amounts of these foods, there is some evidence that while children may be able to provide reasonable recall of foods consumed, the quantitative estimation of foods was not reliable (Lytle et al., 1993). In adults in the NHANES III, we found the magnitude of underreporting to be higher for amounts of foods reported relative to the reported number of foods (Kant, 2002). Finally, in this cohort, the reported number of LND foods was associated positively with energy but negatively with micronutrient intake, suggesting that it may serve as a measure of diet quality (Kant, 2003).

All statistical analyses were performed using SAS (SAS Institute Inc., 2000), and software designed for analysis of survey data (SUDAAN) (Shah, Barnwell, & Bieler, 1997). This software generates variance estimates that are corrected for the multi-stage, stratified probability design of complex surveys. Sample weights provided by the NCHS to correct for differential probabilities of selection, non-coverage, and non-response were used in all analyses to obtain point estimates (National Center for Health Statistics, 1994).

Predictors of LND food reporting

We used sex-specific regression procedures to identify the predictors of the reported number of LND foods. All potential predictors considered are listed in Table 1. Initially, we examined the contribution of each individual socio-demographic, lifestyle, and food consumption related variable for predicting the reported number of LND foods by adding each variable into an age and race adjusted model. Next, all putative predictors were entered into a large multiple linear regression model to determine the independent predictive ability of each variable in the presence of other possible predictors. As an alternative analysis, we ran Poisson regression (using the LOGLINK procedure in SUDAAN), where the reported number of LND foods variable was approximated by a Poisson distribution. All estimates and significant predictors in these Poisson regression models were comparable to those obtained with multiple linear regression procedures. Therefore, in this paper, we present results of linear regression modeling.

We used cross-validation to determine the validity of the model for predicting the number of LND foods reported. The analytic sample was split in half by randomly assigning individuals in each primary sampling unit (PSU) to one of two groups. The significant predictors and the extent of explained variability in the reported number of LND foods in each split sample were comparable. It should be noted that because the observations in the two half-samples came from the same PSUs, it results in a small dependence between the analyses of the two-half-samples. Using an alternative approach of selecting one PSU for each half-sample, would have overly complicated the variance estimation given the complex survey design of NHANES III.

Results

Table 1 shows the number (mean and se) of LND foods reported by males and females in various categories of socio-demographic, family, life-style, and food consumption related variables. The table also identifies variables that were significant predictors of the reported number of LND foods in preliminary regression models containing the variable along with age and race/ethnicity. For females, region of the country, poverty income ratio, family respondent education level, the number of eating occasions, total amount of all foods and beverages reported, the amount of the five major food groups reported, energy intake, and the weekly frequency of consuming a complete school lunch were significant predictors in these preliminary regression models. For males, significant predictors included family size, hours of exercise, the number of eating occasions, total amount of all foods and beverages reported, energy intake and the weekly frequency of consuming a complete school lunch and breakfast.

The multivariate linear regression models with all potential predictors listed in Table 1 explained 57 and 58% of the variance in the number of LND foods reported by males and females, respectively. The variables related to food consumption-the number of eating occasions, amount of foods from the major food groups, and the amount of all foods and beverages reported, were the strongest predictors of the number of LND foods reported. With the exception of age and race, none of the other socio-demographic, lifestyle, or weight-related variables were significant in this model (data not shown; available from authors). Table 2 shows the results of reduced regression models with age, race, the number of eating occasions, amount of foods from the major food groups, amount of all foods and beverages reported, energy intake, and the weekly frequency of school lunch consumption, as predictors. These abbreviated models yielded an R^2 of 0.55 in both males and females.

Discussion

The results suggest that apart from food consumption related variables, a large number of socio-demographic, lifestyle, body weight, and family characteristics that may intuitively be thought to relate to reporting of LND foods were not found to be significant independent predictors of LND foods reported in a 24-h recall. To our knowledge, no other directly comparable published work of descriptors of LND food reporting is available. The closest published study of predictors of high-fat/LND snack consumption examined data from two national surveys—NHANES II and the 1987 National Adolescent Student Health Survey (NASHS) for 12–17 year olds (Dausch, Story, Dresser, Gilbert, Portnoy & Kahle, 1995). This study did not examine most of the predictors included in the present study except geographical region of residence and dieting history. In the NHANES II, neither region nor dieting history were significant independent predictors; in NASHS, however, both were significant predictors, but explained very small extent of variance.

The results suggest the need for intervention trials to examine whether increased access and availability of attractive nutrient-dense foods while decreasing access to LND foods in schools, homes, and other places (Nestle & Jacobson, 2000) will help in moderating LND food and total energy intake. For example, a recent study suggests that family based interventions that focused on increasing fruit and vegetable intake were also effective in reducing the intake of LND foods for both parents and children (Epstein, Gordy, Raynor, Beddome, Kilanowski & Paluch, 2001).

We found the reported number of eating episodes to be an independent positive predictor of the number of LND foods reported by both males and females. Others have also found the number of eating occasions to be associated with high sugar intake (Cusatis & Shannon, 1996; Dwyer, Evans, & Stone, et al., 2001). However, the implication of this

Table 1
The number of low-nutrient-density foods reported by 8–16 year old children and adolescents in a 24-h recall, by socio-demographic, family, body weight, lifestyle, and food consumption related characteristics. NHANES III, 1988–1994

	Males			Females		
	Mean	SE	*n*	Mean	SE	*n*
All	4.7	0.1	2024	4.7	0.1	2113
Socio-demographic characteristics						
Agegroup						
8–10 years	4.6	0.2	815	4.5	0.2	759
11–13 years	4.7	0.2	660	4.9	0.2	719
14–16 years	4.7	0.1	549	4.6	0.2	635
Race/ethnicity						
Non-Hispanic white	4.8	0.1	515	4.9	0.2	566
Non-Hispanic black	4.3	0.1	713	4.5	0.1	737
Mexican–American	3.7	0.1	703	4.1	0.1	716
Other	5.2	0.7	93	3.6	0.2	94
Area of residence						
Metropolitan	4.6	0.2	992	4.7	0.2	1002
Non-metropolitan	4.7	0.1	1032	4.7	0.2	1111
Region of country[a]						
Northeast	4.8	0.2	235	4.9	0.3	224
Midwest	4.9	0.2	354	5.3	0.2	376
West	4.5	0.4	569	3.9	0.2	565
South	4.6	0.2	866	4.6	0.1	948
Family characteristics						
Family size[b]						
1–2	4.9	0.4	89	4.3	0.3	86
3	4.9	0.3	264	4.6	0.3	297
4	5.0	0.2	526	4.9	0.1	568
≥5	4.4	0.1	1145	4.6	0.1	1162
Family respondent highest grade[a]						
<12 years	4.1	0.2	828	4.2	0.2	880
12 years	4.9	0.2	675	4.7	0.2	636
>12 years	4.8	0.2	507	4.9	0.1	585
Poverty income ratio[a]						
First tertile (≤1.43)	4.5	0.2	983	4.3	0.2	1019
Second tertile (>1.43–2.8)	4.6	0.2	504	4.5	0.2	556
Third tertile (>2.8)	5.0	0.2	368	5.2	0.2	381
Body weight related characteristics						
Body mass index (kg/m^2)						
First tertile (≤17.8)	4.8	0.2	748	4.6	0.1	661
Second tertile (≥17.8– ≤21)	4.7	0.2	629	4.9	0.2	588
Third tertile (>21)	4.5	0.2	622	4.5	0.2	832
Tried to lose weight in the last 12 months?						
Yes	4.4	0.2	228	4.8	0.2	494
No	4.7	0.1	1761	4.6	0.1	1574
Self-perceived body weight						
Over weight	4.6	0.2	378	4.7	0.3	624
Under weight	4.8	0.2	276	4.9	0.3	191
Right weight	4.7	0.2	1336	4.6	0.1	1251
Life-style related characteristics						
Supplement use in the past month?						
Yes	4.8	0.2	401	4.8	0.2	473
No	4.6	0.1	1614	4.6	0.1	1629

Table 1 (*continued*)

	Males			Females		
	Mean	SE	*n*	Mean	SE	*n*
Number of hours spent on exercise in the past week[b]						
≤1	4.4	0.4	151	4.3	0.2	300
2	4.7	0.3	220	4.3	0.2	283
3	4.3	0.4	231	4.5	0.2	346
4	4.7	0.3	177	5.0	0.4	202
5	4.4	0.2	406	4.7	0.2	424
6–7	5.0	0.2	472	4.7	0.3	335
>7	5.0	0.3	292	5.5	0.4	144
Average hours of television watched yesterday						
0	4.4	0.4	62	5.0	0.3	82
≤1	4.6	0.2	303	4.7	0.1	374
>1–3	4.7	0.1	1077	4.6	0.2	1084
>4	4.8	0.2	581	4.6	0.2	573
Food intake related characteristics						
Day of recall						
Monday–Thursday	4.7	0.1	1017	4.7	0.2	1007
Friday–Sunday	4.8	0.1	1079	4.5	0.2	1034
Number of eating occasions reported[a,b]						
1–3	2.9	0.1	534	3.0	0.1	565
4	4.1	0.1	679	4.4	0.2	663
>4	5.9	0.2	811	5.6	0.2	885
Amount of all foods and beverages reported (g)[a,b]						
First tertile (<1439)	3.5	0.1	638	3.9	0.2	952
Second tertile (1439–2015)	4.2	0.1	638	4.8	0.1	712
Third tertile (>2015)	5.7	0.2	748	5.8	0.2	449
Amount of foods and beverages from the five major food groups (g)[a]						
First tertile (<816)	4.8	0.2	548	4.9	0.2	904
Second tertile (816–1258)	4.7	0.2	699	4.7	0.2	671
Third tertile (>1258)	4.6	0.1	777	4.2	0.2	538
Energy intake (kcals)[a,b]						
First tertile (<1634)	3.4	0.2	585	3.8	0.1	926
Second tertile (1694–2420)	4.3	0.1	683	5.1	0.1	743
Third tertile (>2420)	5.6	0.2	756	5.9	0.2	444
Mentioned the five major food groups in the recall						
Yes	4.6	0.2	811	4.6	0.1	838
No	4.7	0.1	1213	4.7	0.1	1275
Number of times/week eat a complete school breakfast[b]						
0	4.8	0.1	1283	4.7	0.1	1416
1–2	4.3	0.5	79	4.8	0.5	99
3–4	4.6	0.5	74	4.8	0.6	85
5	4.1	0.2	525	4.2	0.2	445
Number of times/week eat a complete school lunch[a,b]						
0	5.2	0.2	249	5.1	0.2	370
1–2	5.0	0.3	125	5.1	0.3	180
3–4	4.1	0.3	106	4.6	0.3	179
5	4.5	0.2	1502	4.4	0.1	1352

Using linear regression models adjusted for age and race, we tested the contribution of each variable listed above for predicting the reported number of low-nutrient-density foods as outcome. Respondents missing information on a covariate were excluded from these models. Variables without a superscript were not significant predictors ($p > 0.05$).

[a] Significant predictor (≤ 0.05) in age and race-adjusted regression models in females.

[b] Significant predictor (≤ 0.05) in age and race-adjusted regression models in males.

Table 2
Results of regression models for predicting the number of low-nutrient-density foods reported by 8–16 year old children and adolescents in a 24-h recall: NHANES III, 1988–1994

Independent variable	Males			Females		
	β	SE	P	β	SE	P
Intercept	1.09	0.45	0.02	1.54	0.5	0.004
Age at interview (y)	−0.07	0.03	0.03	−0.09	0.03	0.006
Race						
Non-Hispanic white	Reference			Reference		
Non-Hispanic black	0.05	0.11	0.7	0.01	0.1	0.9
Mexican–American	−0.34	0.13	0.009	−0.11	0.12	0.4
Other	−0.09	0.23	0.7	−0.04	0.14	0.8
Number of times/week eat a complete school lunch	−0.08	0.03	0.01	−0.09	0.02	0.001
Number of eating occasions reported	0.82	0.06	<0.0001	0.69	0.08	<0.0001
Amount of foods from the five major food groups (g × 10^2)	−0.20	0.01	<0.0001	−0.30	0.02	<0.0001
Amount of all foods and beverages (g × 10^2)	0.08	0.02	0.002	0.15	0.03	<0.0001
Energy intake (kcal × 10^2)	0.08	0.02	0.0001	0.09	0.02	<0.0001
Model R^2	0.55			0.55		

All independent variables except race were continuous. Respondents missing information on a covariate were excluded from these models. The final regression models included 1982 males and 2081 females with complete covariate information.

observation is not simple, because the frequency of eating occasions also correlates positively with consuming the major nutrient-dense food groups and dietary diversity (Cusatis & Shannon, 1996). Clearly, then the focus has to be on the kinds of foods selected at various eating occasions rather than the number of eating occasions. The weekly frequency of school lunch consumption was a modest negative correlate of the reported number of LND foods in multivariate models in both males and females. Dausch et al. (1995), also found that lunch source of home or school was associated with lower consumption of high-fat/LND snack consumption.

In the present study, we examined several variables related to income, and concern about body weight; after adjustment for age and race, none were found to be significant predictors of the number of LND foods reported in a 24-h recall. Adolescents in focus-group discussions perceived concerns about body image and cost factors to be of lesser importance for food selection (Neumark-Sztainer, Story, Perry, & Casey, 1999).

Table 2 shows that only about 55% of the variance in the number of LND foods reported in a 24-h recall was explained by variables in the final regression models. In focus-group discussions, adolescents perceived hunger/food craving, taste, time constraints, and convenience, to be important factors influencing their food selection (Neumark-Sztainer, Story, Perry & Casey, 1999). Therefore, it is conceivable that a large extent of the unexplained variance in reported LND consumption may be due to lack of information on variables measuring food taste, convenience, and availability factors. Finally, information about parental supervision of food consumption and frequency of working by adolescents was not available for this population; these factors may also contribute to unexplained variance in the reported number of LND foods. Some of the unexplained variability is also due to random within-subject variance, which may be large in this study since the reported number of LND foods was estimated from a single 24-h recall. Dietary predictors were also collected from the single 24-h recall, the resulting variability for these variables will attenuate their corresponding regression coefficients toward zero in the prediction models, thereby lowering the power for detecting significant predictors. Despite these effects from measurement error, we were able to estimate important significant predictors of the reported number of LND foods.

The extent and the nature of dietary misreporting in children and adolescents is poorly understood (Livingstone & Robson, 2000). The extent of misreporting is believed to be related with gender, age, adiposity, and body image (Livingstone & Robson, 2000). The LND foods may be especially likely to be misreported due to the social undesirability of reporting such foods (Livingstone & Robson, 2000). The implications of differential under-reporting of different types of foods by socio-demographic characteristic may have contributed to attenuation of the regression coefficients, and requires further study.

In conclusion, the results suggest that few socio-demographic or lifestyle factors independently predicted the number of LND foods reported by 8–16 year old US children in a 24-h dietary recall. However, characteristics of the recalled diet were predictors of LND food reporting.

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